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**RISK ASSESSMENT FOR
DEAD CREEK SECTOR B
AND SITES L AND M,
SAUGET-CAHOKIA, ILLINOIS**

April 28, 1992

Prepared for

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April 28, 1992

Geraghty & Miller, Inc. is submitting this report to Monsanto Company for a risk assessment of Sector B and Sites L and M of Dead Creek in Sauget-Cahokia, Illinois. The report was prepared in conformance with Geraghty & Miller's strict quality assurance/quality control procedures to ensure that the report meets the highest standards in terms of the methods used and the information presented. If you have any questions or comments concerning this report, please contact one of the individuals listed below.

Respectfully submitted,

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INTRODUCTION

At the request of the Monsanto Company of St. Louis, Missouri, Geraghty & Miller, Inc. Risk Evaluation Group has prepared a risk assessment for Dead Creek Sector B and Sites L and M, located in Sauget-Cahokia, Illinois (Figure 1). This risk assessment supplements a previous site investigation report prepared by Geraghty & Miller on March 30, 1992 (Geraghty & Miller, Inc., 1992). A description of the site, site history, previous investigations, and field activities was provided in that report and is not repeated here. This risk assessment report is organized into five major sections: Exposure Pathways, Data Summary, Approach and Methods, Risk Characterization, and Finding and Conclusions.

EXPOSURE PATHWAYS

Dead Creek Sector B and Sites L and M are surrounded by a chain-link fence; thus, access is restricted. Dead Creek Sector B and Site M (a pond) are not used for either fishing or swimming. Site L is covered with cinders and is used as a parking area for heavy machinery. Current on-site exposure to constituents in Dead Creek or Sites L and M is unlikely. The nearest residential communities are located adjacent to Site M along the eastern border and about 1,000 feet east of Site L. Several homes near Site M have private wells which are used for irrigation purposes (Ecology & Environment Inc., 1988). Private wells have not been identified in the small community located east of Site L. Both communities are located hydraulically upgradient from Dead Creek. Any wells in these areas would not be impacted from constituents that could potentially be released from the sites. Thus, no exposure pathways for ground water exist. The only current exposure pathways from the sites include emission of vapors and/or dust to the air and wind transport to the residential communities.

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DATA SUMMARY

Data collected by Geraghty & Miller during the 1991-1992 site investigation were tabulated to represent the occurrence of constituents at various portions of the site (Figure 1). Sediment data were summarized into four groups: Southern section of Dead Creek Sector B, central section of Dead Creek Sector B, Site M, and Site L (Tables 1 through 4, respectively). In addition, one surface-water sample was collected from the southern shoreline of Site M (Table 5). The data summary tables divide the constituents into three groups: volatile organic compounds (VOCs), semi-volatile organic compounds (semi-VOCs), and inorganics. Pesticides were not detected and the analytes requested for each sample point varied within the study area (see Table 2-1 in Geraghty & Miller, Inc. 1992). Other information provided in the data summary tables includes frequency of detection, range of detected concentrations, arithmetic mean concentration, the one-tailed 95 percent upper confidence limit (UCL) of the arithmetic mean, and the exposure point concentration (EPC). The EPC was used to predict air emission rates from the site and is the lesser of the maximum detected concentration or the UCL. Semi-VOCs and inorganics were the most prevalent constituents. More than 30 semi-VOCs were identified and polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) were most prevalent. Twenty-two inorganics and eight VOCs were detected. Chlorobenzene was the most prevalent VOC identified.

APPROACH AND METHODS

Constituents present in sediments and surface water at Dead Creek Sector B and Sites L and M may be released to the air. VOCs present in subsurface soils at Site L may vaporize and migrate into the air. During several months of the year, portions of Dead Creek Sector B are dry. During these months, the potential exists for vapor and fugitive dust emissions from the sediments. Site M contains water throughout the year; therefore, vapor and fugitive dust emissions from this site are unlikely.

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All of the organic constituents detected in subsurface soils at Site L and in sediments from Dead Creek Sector B were included in this assessment. Benzoic acid, detected in surface water at Site M, was not included because this constituent will not be expected to vaporize from water. Several constituents were detected in Site M sediments. Exposure to these constituents was not evaluated for several reasons. First, the pond contains water throughout the years precluding fugitive dust emissions. Second, VOCs present in the sediments could vaporize, migrate through the water and reach the air; however, the resulting concentrations were expected to be negligible based on the measured concentrations in sediments and the amount of dilution expected as the constituents move into the water column.

AIR RELEASE ANALYSIS

The ambient air concentrations of constituents potentially released from Dead Creek Sector B sediments and Site L subsoils as vapors and from Dead Creek sediments as particulates (fugitive dust) were calculated utilizing two approaches. The near-field box model approach (Pasquill, 1975; Horst, 1979) was used to evaluate potential current exposure in the residential area east of Site M. This methodology is applicable to those exposure scenarios where the receptor population is on-site or very close to the site. The near-field box model is appropriate for evaluating air exposures involving short downwind distances (i.e., less than 100 meters). The infinite line source Gaussian dispersion model (Turner, 1970) was used to evaluate potential exposure in the residential community approximately 1,000 feet east of Dead Creek Sector B and Site L. This approach is appropriate for evaluating air exposures at downwind distances greater than 100 meters from long, narrow sources.

The near-field box model is based on the assumption that dispersion in the air does not occur very close to the source. Uniform dispersion of constituents within the box is assumed. The box model is conservative since the concentrations of constituents are assumed to remain constant within the confines of the box. Similarly, wind speed is held constant in the box even though wind speeds actually increase with height from the ground surface. Figure 2 is a diagram of the near-field box model.

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The infinite line source Gaussian dispersion model considered Dead Creek Sector B, Site M, and Site L to be a line source and assumed an average rate of emission for vapor-phase and particle-bound constituents. The emission rates, in units of micrograms (μg) per unit source length (meters) per unit time (seconds), were calculated by summing the absolute emission values ($\mu\text{g}/\text{second}$) and dividing by the total length of the source (1,320 feet).

VOLATILE CONSTITUENT EMISSION RATE CALCULATION

The emission rate for each VOC constituent to the atmosphere (Q_{vol}) was calculated using the Farmer Model (Farmer et al., 1980), presented as Equation 3 in Table 6. Vapor-phase emissions were calculated for all VOCs and semi-VOCs. The main inputs to this model are the soil-gas diffusion coefficient (D_g); the concentration of constituent in soil vapor (C_g); and the thickness of clean soil cover (T), which in the absence of site-specific data, is assumed to be 1 centimeter (cm) (the model default value) in the creek bed sediments. The value of T used for Site L subsurface soils was 91 cm (3 feet) because the impacted subsurface soils were found to occur at a depth of 3 feet. To calculate D_g (Equation 2 in Table 6), the site-specific soil parameters total porosity (P_{tot}) and air-filled porosity (P_{af}) were assumed to be the same, using a default value of $0.5 \text{ cm}^3/\text{cm}^3$ for sandy-silt soils. C_g was calculated using the method of Hwang and Falco (1986), shown as Equation 1 in Table 6.

The calculated volatile emission rate (Q_{vol}) for each VOC was used as an input into the near-field box model and the infinite line source model to calculate their estimated concentrations in ambient air.

PARTICULATE-BOUND CONSTITUENT EMISSION RATE CALCULATION

Airborne particulates with an aerodynamic diameter of 10 microns or less (PM_{10}) are respirable and may be a source of inhalation exposure to particulate-bound constituents (Cowherd et al., 1984). Emission rates for PM_{10} were calculated using the methods described in Cowherd et al. (1984). Table 7 presents the equations used in this analysis.

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For this assessment, the sediments in the Sector B creek bed site are assumed to have an "unlimited reservoir" of wind-erodible surface particles. To make a more accurate determination of site soils (unlimited versus limited reservoir), particle-size distribution information is required. Because this information was not available, it was assumed that all the soils were available for wind erosion. The PM_{10} emissions factor, E_{10} is dependent on the threshold wind velocity (Equation 1 in Table 7) and the surface characteristics of the site, as shown in Equation 2 of Table 7.

The constituent-specific emission rates were determined by first calculating the total PM_{10} emission rate (Equation 3 in Table 7), then multiplying the result by the mass fraction of the constituent in soil (using the 95 percent UCL in units of micrograms per microgram ($\mu g/\mu g$)). The resulting particulate emission rate (Q_{pm}), expressed in micrograms per cubic meter ($\mu g/m^3$), was used in the near-field box model to estimate ambient air concentrations of particle-bound constituents.

ESTIMATED AMBIENT AIR CONCENTRATIONS

The estimated ambient air concentrations (C_a) were calculated by solving the equations in Table 8 and were used as EPCs for estimating risks. The proximity of potential receptors to the site and wind speed were considered. Prevailing winds are from the south 7 months, from the northwest 2 months, and from west northwest 3 months of the year at an average speed of 4.2 meters per second (m/s) (Water Information Center, Inc., 1974). However, as a conservative measure, it was assumed that the receptors were always downwind. Air concentrations in the residential community, which is approximately 1,000 feet west of Dead Creek Sector B and Site L, were estimated using the infinite line source Gaussian dispersion model, based on fugitive dust emissions from sediments from the southern and central sections of the creek bed and vapor emissions from subsurface soils at Site L. These concentrations are shown in Table 9. Ambient air concentrations in the residential community directly east of Site M were calculated based on fugitive dust and vapor emissions from the southern section of Dead Creek Sector B and Site M using the near-field box model and are shown in Table 10.

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RISK CHARACTERIZATION

The constituent concentrations in air predicted by the models were used to calculate risk to residents. Two types of risk estimates are provided: (1) the excess lifetime cancer risk (ELCR) for known or suspected human carcinogens and (2) the hazard quotient (HQ) for all constituents.

The ELCR is a probability estimate of the excess lifetime cancer risk (above background incidence) resulting from exposure to constituents released from the site and is based on a unit risk factor. The unit risk factor is the theoretical risk associated with continuous lifetime exposure to a concentration of $1 \mu\text{g}/\text{m}^3$. ELCRs are calculated by multiplying the predicted air concentration by the unit risk. Unit risk factors are based on the assumption that any exposure to a carcinogen may cause cancer (non-threshold theory). Regulatory guidance specifies that ELCRs in the range of 10^{-4} to 10^{-6} are acceptable (U.S. Environmental Protection Agency [USEPA], 1991a). ELCRs are calculated for each constituent and summed to derive the total ELCR.

HQs are the ratio of the predicted air concentration and the reference concentration (RfC) and are not probability estimates. RfCs are defined as the concentration that humans could be exposed to continuously without experiencing any adverse non-cancer effects. However, RfCs are not a strict demarcation between a toxic and non-toxic dose. HQs for each constituent are summed to derive the hazard index (HI). The regulatory guidance specifies that HQs or HIs greater than one are unacceptable.

Unit risks and RfCs (toxicity values) are available from the Integrated Risk Information System (IRIS) (1992) or the Health Effects Assessment Summary Tables (USEPA, 1991b). Toxicity values used in this report are shown in Tables 9 and 10; however, toxicity values were not available for some of the constituents.

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Risk estimates for current residents of the community about 1,000 feet east of Site L are shown in Table 9. The ELCR was 3×10^{-10} , and the HI was 0.000008. Both estimates were well below the regulatory guidance levels and indicate that the site does not pose a threat to residents in this community.

Risk estimates for current residents of the community east of to Site M are shown in Table 10. The ELCR was 4×10^{-9} , and the HI was 0.00009. These estimates are well below the regulatory guidance levels and indicate that the site does not pose a threat to people currently living next to the site.

The risk estimates provided in this report are conservative, meaning that the actual risks are likely to be much lower. The exposure point concentrations were calculated assuming the receptors were always directly downwind of the site, which is not the case for most of the year. The risk models assumed continuous lifetime exposure to the predicted concentrations and the toxicity values are based on conservative assumptions, which almost certainly result in overestimates of risks. The missing toxicity values were not considered significant in this case because the predicted concentrations were very low and the risk estimates for current exposure were 3 to 5 orders of magnitude lower than the regulatory guidance.

The predicted concentrations at current receptor points were also below current analytical detection limits and below measured ambient concentrations in the United States. For example, PCBs are probably the primary constituent of concern at the site in terms of prevalence, concentration, and toxicity and are ubiquitous environmental contaminants. Typical atmospheric concentrations range from $2 \times 10^{-3} \mu\text{g}/\text{m}^3$ to $5 \times 10^{-4} \mu\text{g}/\text{m}^3$ (in remote areas) to $3 \times 10^{-3} \mu\text{g}/\text{m}^3$ (in urban areas) (Agency for Toxic Substances and Disease Registry [ATSDR], 1991). For comparison, the predicted PCB concentration at the nearest residential community was $1.1 \times 10^{-7} \mu\text{g}/\text{m}^3$ (Table 10).

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FINDINGS AND CONCLUSIONS

Sediment data collected from Dead Creek Sector B and Sites L and M and surface-water data collected from Site M were evaluated for risks posed to nearby communities. Access to the property is restricted by a chain-link fence and no wells are located downgradient from the site. Air emissions (vapors and particulates) were modeled, and concentrations occurring at the nearest residential communities were predicted. Based on the modeled concentrations, ELCR estimates ranged from 3×10^{-10} to 4×10^{-9} and were well below the regulatory guidance of 10^{-4} to 10^{-6} . Likewise, the HIs ranged from 0.000008 to 0.00009 and were well below the regulatory guidance of one. Therefore, Dead Creek Sector B and Sites L and M do not pose a health threat to residential communities located near the site.

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TABLES

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Table 1. Occurrence of Constituents in Sediment, Dead Creek Sector B, Southern Section, Saugat-Cabokia, Illinois.

Constituent	Frequency	Range of Detects	Mean	UCL	EPC
	Detects / Total	Min - Max			
<u>VOCs</u>					
Acetone	1 / 5	1.7 - 1.7	0.66	1.3	1.3
Carbon disulfide	4 / 5	0.008 - 0.063	0.036	0.06	0.06
Chlorobenzene	5 / 5	0.44 - 2	1.2	1.9	1.9
Toluene	2 / 5	0.035 - 5.3	1.1	3.3	3.3
Xylenes	2 / 5	0.04 - 0.36	0.094	0.24	0.24
<u>Semi-VOCs</u>					
Acenaphthene*	3 / 5	0.27 - 0.53	0.44	0.54	0.53
Acenaphthylene*	1 / 5	0.96 - 0.96	0.58	0.92	0.92
Anthracene*	4 / 5	0.13 - 1.8	0.91	1.7	1.7
Benzo(a)anthracene**	5 / 5	0.48 - 3.7	1.7	2.9	2.9
Benzo(b)fluoranthene**	5 / 5	1.1 - 30	8	20	20
Benzo(k)fluoranthene**	5 / 5	0.67 - 15	4.4	10	10
Benzo(g,h,i)perylene*	5 / 5	0.38 - 13	3.4	8.5	8.5
Benzo(a)pyrene**	5 / 5	0.55 - 10	3.2	6.9	6.9
bis(2-Ethylhexyl)phthalate	5 / 5	1.2 - 12	4.8	9.3	9.3
2-Chlorophenol	3 / 5	0.12 - 0.46	0.33	0.5	0.46
Chrysene**	5 / 5	0.84 - 9.4	3.1	6.5	6.5
Dibenzo(a,h)anthracene**	1 / 5	3.9 - 3.9	1.8	3.6	3.6
Dibenzofuran*	3 / 5	0.17 - 1.3	0.71	1.2	1.2
1,2-Dichlorobenzene	3 / 5	0.96 - 1.7	1.2	1.7	1.7
1,3-Dichlorobenzene	4 / 5	0.18 - 0.76	0.55	0.8	0.76
1,4-Dichlorobenzene	5 / 5	1.6 - 2.3	1.9	2.1	2.1
2,4-Dichlorophenol	2 / 5	0.34 - 0.88	0.66	0.95	0.88
Fluoranthene*	5 / 5	0.84 - 5.4	2.4	4.3	4.3
Fluorene*	4 / 5	0.17 - 1.6	0.93	1.6	1.6
Hexachlorobenzene	1 / 5	0.11 - 0.11	0.11	0.11	0.11
Indeno(1,2,3-c,d)pyrene**	4 / 5	0.27 - 9	3.4	7.1	7.1
2-Methylnaphthalene*	3 / 5	0.1 - 1.8	0.84	1.7	1.7
Naphthalene*	4 / 5	0.3 - 5.1	2.4	4.8	4.8
N-nitrosodiphenylamine	1 / 5	0.76 - 0.76	0.61	0.81	0.76
Pentachlorophenol	3 / 5	1.5 - 2.9	2.4	3.1	2.9
Phenanthrene*	5 / 5	0.41 - 6.4	2	4.4	4.4
Pyrene*	5 / 5	2.5 - 7.5	5.1	7.1	7.1
PAHs (carcinogenic)	4 / 5	3.91 - 81	22	54	54
PAHs (total)	5 / 5	8.78 - 126.39	40	87	87
PCBs	10 / 15	0.13 - 440	84	150	150
1,2,4-Trichlorobenzene	5 / 5	1.6 - 4.4	3.3	4.3	4.3
2,4,5-Trichlorophenol	1 / 5	0.096 - 0.096	0.096	0.096	0.096
2,4,6-Trichlorophenol	2 / 5	0.35 - 1.4	0.98	1.5	1.4

Footnotes appear on page 2.

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Table 1. Occurrence of Constituents in Sediment, Dead Creek Sector B, Southern Section, Sauget-Cahokia, Illinois.

Constituent	Frequency	Range of Detects	Mean	UCL	EPC
	Detects / Total	Min - Max			
Inorganics					
Aluminum	5 / 5	5,780 - 49,200	17,000	34,000	34,000
Antimony	4 / 5	20.3 - 41.9	25	37	37
Arsenic	5 / 5	63.1 - 198	110	160	160
Barium	5 / 5	1,980 - 8,640	5,200	8,100	8,100
Cadmium	5 / 5	22 - 69.6	44	61	61
Calcium	5 / 5	12,500 - 20,400	16,000	19,000	19,000
Chromium	5 / 5	71.1 - 296	160	240	240
Cobalt	5 / 5	10.3 - 17.2	13	15	15
Copper	5 / 5	3,160 - 25,100	14,000	22,000	22,000
Cyanide, total	3 / 5	0.78 - 17.4	4.2	11	11
Iron	5 / 5	24,200 - 48,700	37,000	48,000	48,000
Lead	5 / 5	696 - 2,660	1,600	2,300	2,300
Magnesium	5 / 5	3,030 - 3,660	3,300	3,600	3,600
Manganese	5 / 5	96.4 - 153	120	140	140
Mercury	5 / 5	1.1 - 5	2.8	4.4	4.4
Nickel	5 / 5	292 - 1,260	770	1,200	1,200
Potassium	5 / 5	830 - 2,030	1,200	1,700	1,700
Selenium	5 / 5	4.4 - 9.45	6.4	8.2	8.2
Silver	5 / 5	5.1 - 21	14	20	20
Vanadium	5 / 5	16.4 - 54.8	33	47	47
Zinc	5 / 5	5,140 - 26,100	15,000	22,000	22,000

Concentrations are given in milligrams per kilogram (mg/kg).

* Non-carcinogenic polycyclic aromatic hydrocarbons (PAHs).

** Carcinogenic PAHs (also considered in total PAHs).

EPC Exposure point concentration.

Mean Arithmetic average of the total number of samples.

PCBs Polychlorinated biphenyls.

Semi-VOCs Semivolatile organic compounds.

UCL 95 percent upper confidence limit (one-tailed normal distribution) on the arithmetic mean.

VOCs Volatile organic compounds.

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Table 2. Occurrence of Constituents in Sediment, Dead Creek Sector B, Central Section, Sauget-Cahokia, Illinois.

Constituent	Frequency	Range of Detects	Mean	UCL	EPC
	Detects / Total	Min - Max			
<u>VOCs</u>					
Acetone	2 / 5	0.24 - 0.29	0.18	0.26	0.26
2-Butanone	1 / 5	0.2 - 0.2	0.089	0.16	0.16
Carbon disulfide	5 / 5	0.01 - 0.035	0.016	0.026	0.026
Chlorobenzene	5 / 5	0.092 - 13	3.1	8.4	8.4
Ethylbenzene	3 / 5	0.008 - 0.044	0.018	0.032	0.032
Tetrachloroethene	1 / 5	0.03 - 0.03	0.017	0.027	0.027
Toluene	2 / 5	0.025 - 0.069	0.025	0.049	0.049
Xylenes	1 / 5	0.044 - 0.044	0.024	0.038	0.038
<u>Semi-VOCs</u>					
Acenaphthene*	3 / 5	0.098 - 2.6	0.79	1.8	1.8
Anthracene*	2 / 5	1.3 - 2.7	1	2	2
Benzo(a)anthracene**	4 / 5	0.36 - 5.4	2.4	4.8	4.8
Benzo(b)fluoranthene**	4 / 5	0.77 - 6.1	2.9	5.5	5.5
Benzo(k)fluoranthene**	4 / 5	0.78 - 5.2	2.5	4.8	4.8
Benzo(g,h,i)perylene*	4 / 5	0.33 - 3.2	1.4	2.6	2.6
Benzo(a)pyrene**	5 / 5	0.17 - 5.3	2.3	4.6	4.6
bis(2-Ethylhexyl)phthalate	3 / 5	0.086 - 0.91	0.53	0.85	0.85
2-Chlorophenol	1 / 5	0.11 - 0.11	0.11	0.11	0.11
Chrysene**	4 / 5	0.51 - 7	2.8	5.6	5.6
Dibenzofuran*	3 / 5	0.07 - 2	0.62	1.4	1.4
1,2-Dichlorobenzene	2 / 5	2.5 - 11	3	7.3	7.3
1,3-Dichlorobenzene	3 / 5	0.41 - 2	0.85	1.5	1.5
1,4-Dichlorobenzene	5 / 5	0.11 - 12	4	8.8	8.8
2,4-Dichlorophenol	2 / 5	0.096 - 0.25	0.22	0.28	0.25
2,4-Dimethylphenol	2 / 5	0.087 - 0.14	0.13	0.15	0.14
Fluoranthene*	4 / 5	0.43 - 5.2	2.3	4.6	4.6
Fluorene*	4 / 5	0.12 - 4.6	1.2	3.1	3.1
Indeno(1,2,3-c,d)pyrene**	4 / 5	0.46 - 2.8	1.3	2.3	2.3
Isophorone	1 / 5	0.27 - 0.27	0.27	0.27	0.27
2-Methylnaphthalene*	3 / 5	0.14 - 7	1.6	4.5	4.5
4-Methylphenol	1 / 5	0.12 - 0.12	0.12	0.12	0.12
Naphthalene*	4 / 5	0.19 - 2.1	0.69	1.5	1.5
Pentachlorophenol	3 / 5	0.32 - 1.6	1.1	1.8	1.6
Phenanthrene*	4 / 5	0.32 - 2.9	1.1	2.2	2.2
Pyrene*	4 / 5	1.2 - 16	6.3	13	13
PAHs (carcinogenic)	5 / 5	0.17 - 30.3	14	27	27
PAHs (total)	5 / 5	0.17 - 67.1	28	58	58
PCBs	11 / 15	0.12 - 301	44	82	82
1,2,4-Trichlorobenzene	3 / 5	0.38 - 12	3.1	7.9	7.9

Footnotes appear on page 2.

CER 007697

GERAGHTY & MILLER, INC.

Table 2. Occurrence of Constituents in Sediment, Dead Creek Sector B, Central Section, Sangre-Cabotia, Illinois.

Constituent	Frequency	Range of Detects	Mean	UCL	EPC
	Detects / Total	Min - Max			
<u>Inorganics</u>					
Aluminum	5 / 5	5,640 - 15,400	10,000	14,000	14,000
Antimony	4 / 5	20.7 - 44.5	32	48	45
Arsenic	5 / 5	52.9 - 95.7	78	95	95
Barium	5 / 5	1,890 - 9,510	5,300	8,800	8,800
Cadmium	5 / 5	71.8 - 243	120	190	190
Calcium	5 / 5	7,760 - 23,600	13,000	19,000	19,000
Chromium	5 / 5	63.1 - 125	100	120	120
Cobalt	5 / 5	12.2 - 29.9	22	29	29
Copper	5 / 5	3,560 - 30,100	14,000	24,000	24,000
Cyanide, total	4 / 5	0.53 - 1.5	0.77	1.2	1.2
Iron	5 / 5	31,700 - 86,400	54,000	75,000	75,000
Lead	5 / 5	1,340 - 2,310	1,700	2,100	2,100
Magnesium	5 / 5	2,570 - 4,040	3,400	4,000	4,000
Manganese	5 / 5	128 - 557	240	410	410
Mercury	5 / 5	0.14 - 3.9	1.3	2.8	2.8
Nickel	5 / 5	548 - 2,670	1,500	2,300	2,300
Potassium	4 / 5	796 - 2,420	1,400	2,200	2,200
Selenium	4 / 5	3.7 - 8.7	4.7	6.9	6.9
Silver	5 / 5	4.2 - 50.4	19	37	37
Sodium	2 / 5	215 - 452	220	350	350
Vanadium	5 / 5	44.1 - 58.9	52	58	58
Zinc	5 / 5	4,500 - 42,800	20,000	36,000	36,000

Concentrations are given in milligrams per kilogram (mg/kg).

* Non-carcinogenic polycyclic aromatic hydrocarbons (PAHs).

** Carcinogenic PAHs (also considered in total PAHs).

EPC Exposure point concentration.

Mean Arithmetic average of the total number of samples.

PCBs Polychlorinated biphenyls.

Semi-VOCs Semivolatile organic compounds.

UCL 95 percent upper confidence limit (one-tailed normal distribution) on the arithmetic mean.

VOCs Volatile organic compounds.

CER 007698

GERAGHTY & MILLER, INC.

Table 3. Occurrence of Constituents in Sediment, Site M, Saugat-Cahokia, Illinois.

Constituent	Frequency	Range of Detects	Mean	UCL	EPC
	Detects / Total	Min - Max			
VOCs					
Chlorobenzene	1 / 2	10 - 10	5.7	33	10
Ethylbenzene	1 / 2	0.82 - 0.82	0.82	0.82	0.82
Semi-VOCs					
Acenaphthene*	1 / 2	1.5 - 1.5	1.5	1.5	1.5
Anthracene*	2 / 2	2.5 - 3.9	3.2	7.6	3.9
Benzo(a)anthracene**	2 / 2	9.2 - 9.4	9.3	9.9	9.4
Benzo(b)fluoranthene**	2 / 2	8.4 - 15	12	33	15
Benzo(k)fluoranthene**	2 / 2	6.6 - 9.3	8	16	9.3
Benzo(g,h,i)perylene*	2 / 2	6 - 6	6	6	6
Benzo(a)pyrene**	2 / 2	6.9 - 7.5	7.2	9.1	7.5
bis(2-Ethylhexyl)phthalate	1 / 2	18 - 18	13	47	18
Butylbenzylphthalate	1 / 2	1.6 - 1.6	1.6	1.6	1.6
Chrysene**	2 / 2	9.9 - 12	11	18	12
Dibenzo(a,h)anthracene**	1 / 2	1.2 - 1.2	1.2	1.2	1.2
Dibenzofuran*	1 / 2	2.1 - 2.1	2.1	2.1	2.1
1,2-Dichlorobenzene	2 / 2	3.3 - 26	15	86	26
1,3-Dichlorobenzene	2 / 2	2.3 - 4.1	3.2	8.9	4.1
1,4-Dichlorobenzene	2 / 2	27 - 40	34	75	40
Fluoranthene*	2 / 2	21 - 21	21	21	21
Fluorene*	2 / 2	5.2 - 5.9	5.6	7.8	5.9
Indeno(1,2,3-c,d)pyrene**	2 / 2	3.7 - 4.3	4	5.9	4.3
2-Methylnaphthalene*	2 / 2	1.6 - 6.9	4.3	21	6.9
Naphthalene*	2 / 2	2.6 - 3.3	3	5.2	3.3
Phenanthrene*	2 / 2	11 - 13	12	18	13
Pyrene*	2 / 2	23 - 27	25	38	27
PAHs (carcinogenic)	2 / 2	45.3 - 58.1	52	92	58
PAHs (total)	2 / 2	129.9 - 137	130	160	140
PCBs	10 / 10	14.9 - 505	200	290	290
1,2,4-Trichlorobenzene	2 / 2	5 - 14	9.3	38	14
Inorganics					
Aluminum	3 / 3	4,670 - 7,290	6,400	8,900	7,300
Antimony	2 / 3	16.6 - 41.2	24	49	41
Arsenic	3 / 3	7 - 94	42	120	94
Barium	3 / 3	1,760 - 9,060	4,600	11,000	9,100
Cadmium	3 / 3	8.6 - 47.2	24	58	47
Calcium	3 / 3	5,560 - 12,500	9,900	16,000	13,000
Chromium	3 / 3	80 - 183	120	210	180
Cobalt	3 / 3	9.1 - 20.6	16	27	21

Footnotes appear on page 2.

CER 007699

GERAGHTY & MILLER, INC.

Table 3. Occurrence of Constituents in Sediment, Site M, Saugat-Cahokia, Illinois.

Constituent	Frequency	Range of Detects	Mean	UCL	EPC
	Detects / Total	Min - Max			
Copper	3 / 3	8,150 - 21,000	14,000	25,000	21,000
Cyanide, total	1 / 1	1.3 - 1.3	1.3	NA	NA
Iron	3 / 3	16,300 - 48,500	28,000	58,000	49,000
Lead	3 / 3	625 - 1,910	1,100	2,300	1,900
Magnesium	3 / 3	3,090 - 6,200	4,500	7,200	6,200
Manganese	3 / 3	154 - 178	160	190	180
Mercury	3 / 3	0.07 - 0.45	0.3	0.64	0.45
Nickel	3 / 3	959 - 2,490	1,600	2,900	2,500
Potassium	3 / 3	758 - 1,080	940	1,200	1,100
Silver	3 / 3	18 - 26	21	28	26
Sodium	1 / 3	211 - 211	180	230	210
Vanadium	3 / 3	19.3 - 37.7	29	44	38
Zinc	3 / 3	9,930 - 31,600	18,000	38,000	32,000

Concentrations are given in milligrams per kilogram (mg/kg).

* Non-carcinogenic polycyclic aromatic hydrocarbons (PAHs).

** Carcinogenic PAHs (also considered in total PAHs).

EPC Exposure point concentration.

Mean Arithmetic average of the total number of samples.

PCBs Polychlorinated biphenyls.

Semi-VOCs Semivolatile organic compounds.

UCL 95 percent upper confidence limit (one-tailed normal distribution) on the arithmetic mean.

VOCs Volatile organic compounds.

CER 007700

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Table 4. Constituents Detected in Sediment, Site L, Sauget-Cahokia, Illinois.

Constituent	Sediment Concentration (mg/kg)
VOCs	
Chlorobenzene	5.3
Toluene	4.5
Xylenes	0.54
Semi-VOCs	
Acenaphthene*	3.1
Acenaphthylene*	0.28
Anthracene*	4.2
Benzo(a)anthracene**	8.6
Benzo(b)fluoranthene**	5.4
Benzo(k)fluoranthene**	4.6
Benzo(g,h,i)perylene*	3.2
Benzo(a)pyrene**	5.3
Butylbenzylphthalate	5.4
Chrysene**	8.2
Dibenzofuran*	3.0
Di-n-butylphthalate	1.8
1,2-Dichlorobenzene	7.7
1,3-Dichlorobenzene	4.3
1,4-Dichlorobenzene	100
2,4-Dichlorophenol	2.4
4-Chloroaniline	13
Diethylphthalate	1.0
Fluoranthene*	16
Fluorene*	5.0
Hexachlorobenzene	4.8
Indeno(1,2,3-c,d)pyrene**	2.9
2-Methylnaphthalene*	2.3
4-Methylphenol	3.2
Naphthalene*	7.3
Pentachlorophenol	28

Footnotes appear on page 2.

CER 007701

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Table 4. Constituents Detected in Sediment, Site L, Sauget-Cahokia, Illinois.

Constituent	Sediment Concentration (mg/kg)
Phenanthrene*	23
Phenol	13
Pyrene*	23
PAHs (carcinogenic)	35
PAHs (total)	125
PCBs	500
1,2,4-Trichlorobenzene	79
2,4,6-Trichlorophenol	1.5
Inorganics	
Aluminum	7,320
Arsenic	49
Barium	1,440
Cadium	42
Calcium	75,500
Chromium	27
Cobalt	8.3
Copper	308
Cyanide	0.46
Iron	2,400
Lead	664
Magnesium	5,150
Manganese	535
Mercury	1.8
Nickel	95.9
Potassium	1,130
Vanadium	27.6
Zinc	4,240
* Non carcinogenic PAHs.	
** Carcinogenic PAHs (also considered in total PAHs).	
mg/kg	Milligrams per kilogram.
PAHs	Polycyclic aromatic hydrocarbons.
PCBs	Polychlorinated biphenyls.
Semi-VOCs	Semivolatile organic compounds.
VOCs	Volatile organic compounds.

CER 007702

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**Table 5. Constituents Detected in Surface Water, Site M, Sauget-Cahokia,
Illinois.**

Constituent	Surface-Water Concentration ($\mu\text{g/L}$)
<u>Semi-VOCs</u>	
Benzoic acid	3.0
<u>Inorganics</u>	
Barium	140
Calcium	46,000
Copper	200
Iron	270
Lead	11
Magnesium	3,900
Manganese	56
Potassium	3,700
Sodium	20,000
Zinc	130

$\mu\text{g/L}$ Micrograms per liter.
Semi-VOCs Semivolatile organic compounds.

CER 007703

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Table 6. Equation Definitions for Calculation of Soil Sediment Vapor Emissions from Dead Creek Sector B and Sites L and M, Sauget-Cabotia, Illinois.

Finally, the vapor emission rate, Q_{v} ($\mu\text{g}/\text{sec}$), is calculated:

$$Q_{\text{v}} = F \times A$$

where:

A Area over which vapor flux occurs (cm^2): 2,900,000 cm^2 for the central section of Dead Creek, Sector B; 3,300,000 cm^2 for the southern section, and 7,600,000 cm^2 for Site L.

Q_{v} also includes a factor normalizing the value to the number of months of the year that the creek bed is dry: 10 months central section; 2 months southern section. Site L was assumed to have emissions all year. Q_{voc} was then used in the near field box model.

Atm	Atmospheres.
cm	Centimeter.
cm^2	Square centimeters.
cm^3	Cubic centimeters.
g	Gram.
μ	Micrograms.
m^3	Cubic meters.
mol	Moles.
sec	Second.

CER 007704

GERAGHTY & MILLER, INC.

Table 7. Equation Definitions for Calculation of Soil/Sediment Particulate Emissions from Dead Creek Sector B, Sangre-Cabokia, Illinois.

The emission rate of each semi-VOC and metal constituent to the atmosphere is calculated using the Cowherd PM₁₀ emission rate equations. First, the threshold wind speed at a height of 7 m, U_t (m/sec), was calculated.

$$U_t = U(z)/U^* \times (1/0.4) \times \ln(z/z_0) \quad (\text{Eq. 1})$$

where:

U	Wind speed at height z (4.2 m/sec).
z	Height above soil surface (7 m).
U*	Friction velocity (assumed to be 75 cm/sec based on an "unlimited reservoir" of erodible particles).
z ₀	Roughness height, assumed to be 1 cm based on site surface characteristic (values suggested by Cowherd et al. (1984).

Next, the PM₁₀ emission factor, E₁₀ (g/m²-hr), was calculated using the "unlimited reservoir" model (Cowherd et al., 1984):

$$E_{10} = 0.036 \times (1-V) \times (U_m/U_t)^3 \times f(x) \quad (\text{Eq. 2})$$

where:

V	Fraction of total surface area covered by continuous vegetation, assumed to be 0%.
U _m	Mean annual wind speed (4.2m/sec).
f(x)	Value approximated using equation in Appendix B, Cowherd et al., 1984 (0.037, dimensionless).

Finally, the emission rate of PM₁₀, ER₁₀ (μg/sec) was calculated:

$$ER_{10} = ((EF_{10} \times UC_1)/UC_2) \times A_t \quad (\text{Eq. 3})$$

where:

UC ₁	Unit conversion 1 (1 x 10 ⁶ μg/g).
UC ₂	Unit conversion 2 (3,600 sec/hr).
A _t	Surface area: 290 m ² for the central portion of Dead Creek, 330 m ² for the southern portion of Dead Creek.

The constituent-specific emission rate, Q_{em}, was then calculated by multiplying the ER₁₀ by the mass fraction of the chemical in soil (95% UCL, in μg/μg) and applying a factor normalizing the value to the number of months of the year that the creek bed is dry: 10 months central section; 2 months southern section. The Q_{em} was then used in the near field box model.

cm	Centimeter.	μg	Micrograms.
g	Grams.	PM ₁₀	Particulate matter < 10 micrometers in diameter.
hr	Hour.	sec	Seconds.
m	Meter.	semi-VOCs	Semivolatile organic compounds.
m ²	Square meter.	UCL	Upper confidence limit.

CER 007705

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Table 8. Equation Definitions for Calculation of Ambient Air Concentrations using the Near-Field Box Model and the Infinite Line Source Model, Dead Creek Sector B and Sites L and M, Saugat-Cabotia, Illinois.

The emission rates for vapor-phase and particle-bound constituents to the atmosphere are used in the box model to calculate ambient air concentrations, C_{voc} and C_{part} ($\mu\text{g}/\text{m}^3$), in the current residential community located south of Sector B.

$$C = \frac{Q}{Hb \times Wb \times Um} \quad (\text{Eq. 1})$$

where

Q Modeled rate of VOC or PM10 emissions from soil ($\mu\text{g}/\text{sec}$).
Hb Downwind height of box (m), estimated to be 2 m (breathing height).
Wb Width of box, crosswind dimension of affected area, estimated to be 69m.
Um Average wind speed through box (4.2 m/sec).

The emission rates for vapor-phase and particle-bound constituents to the atmosphere are also used in the infinite line source model to calculate ambient air concentrations, C_{voc} and C_{pm} ($\mu\text{g}/\text{m}^3$), in the current residential community located approximately 300 meters east of Site L.

$$\begin{matrix} C_{voc} \\ \text{or} \\ C_{pm} \end{matrix} = \frac{2 \times Q}{2 \times \pi \times \sigma_z \times Um} \quad (\text{Eq. 2})$$

where:

q Emissions per unit length of the line source (g/sec-m); calculated by dividing the total Q ($\mu\text{g}/\text{sec}$) by length of the creek bed (400 m).
 π 3.14, unitless.
 σ_z 11 m, based on Figure 2-3 from Turner (1970), for D stability class.
Um Mean wind speed (m/sec).

C_{voc} Ambient air concentration for volatile organic compounds.
 C_{pm} Ambient air concentration for particulates.
g Grams.
m Meters.
 m^3 Cubic meter.
 μg Micrograms.
sec Second.

CER 007706

GERAGHTY & MILLER, INC.

Table 9. Inhalation Risks and Calculations for Constituents of Concern, Nearest Residential Community, Dead Creek Sector B and Site L, Sauget-Cahokia, Illinois.

Constituent	Ca (ug/m3)	RfC (ug/m3)	Unit Risk (ug/m3)	HQ	ELCR
<u>VOCs</u>					
Acetone	1.1E-06	NA	-	NA	-
2-Butanone	8.5E-09	3.0E+02	-	2.8E-11	-
Carbon disulfide	2.8E-08	1.0E+01	-	2.8E-09	-
Chlorobenzene	1.8E-06	2.0E+01	-	9.0E-08	-
Ethylbenzene	3.0E-09	1.0E+03	-	3.0E-12	-
Tetrachloroethene	4.2E-10	NA	5.2E-07	NA	2.2E-16
Toluene	1.1E-06	2.0E+03	-	5.5E-10	-
Xylenes	6.3E-08	3.0E+02	-	2.1E-10	-
<u>Semi-VOCs</u>					
bis(2-Ethylhexyl)phthalate	5.8E-10	NA	NA	NA	NA
Burylbenzylphthalate	9.1E-12	NA	NA	NA	NA
4-Chloroaniline	2.3E-10	NA	-	NA	-
2-Chlorophenol	3.0E-11	NA	-	NA	-
1,2-Dichlorobenzene	2.3E-07	2.0E+02	-	1.2E-09	-
1,3-Dichlorobenzene	1.6E-07	NA	-	NA	-
1,4-Dichlorobenzene	9.9E-07	7.0E+02	NA	1.4E-09	NA
2,4-Dichlorophenol	5.7E-11	NA	-	NA	-
2,4-Dimethylphenol	1.9E-12	NA	-	NA	-
Diethylphthalate	1.4E-12	NA	-	NA	-
Hexachlorobenzene	6.7E-12	NA	4.6E-04	NA	3.1E-15
Isophorone	3.7E-12	NA	NA	NA	NA
4-Methylphenol	1.7E-12	NA	NA	NA	NA
n-Nitrosodiphenylamine	4.6E-11	NA	NA	NA	NA
PAHs (carcinogenic)	3.7E-09	NA	1.7E-03	NA	6.3E-12
PAHs (total)	6.1E-09	NA	-	NA	-
PCBs	1.0E-08	NA	NA	NA	NA
Pentachlorophenol	2.0E-10	NA	NA	NA	NA
Phenol	5.9E-11	NA	-	NA	-
1,2,4-Trichlorobenzene	1.1E-08	9.0E+00	-	1.2E-09	-
2,4,5-Trichlorophenol	5.9E-12	NA	-	NA	-
2,4,6-Trichlorophenol	8.6E-11	NA	3.1E-06	NA	2.7E-16
<u>Inorganics</u>					
Antimony	2.9E-09	NA	-	NA	-
Arsenic	1.1E-08	NA	4.3E-03	NA	4.7E-11
Barium	6.2E-07	5.0E+01	-	1.2E-08	-
Cadmium	6.4E-09	NA	1.8E-03	NA	1.2E-11
Calcium	2.6E-07	NA	-	NA	-

Footnotes appear on page 2.

CER 007707

GERAGHTY & MILLER, INC.

Table 9. Inhalation Risks and Calculations for Constituents of Concern, Nearest Residential Community, Dead Creek Sector B and Site L, Saugat-Cabokia, Illinois.

Constituent	Ca (ug/m3)	RfC (ug/m3)	Unit Risk (ug/m3)	HQ	ELCR
Chromium	1.6E-08	2.0E-03	1.2E-02	8.0E-06	1.9E-10
Cobalt	4.0E-10	NA	-	NA	-
Copper	1.7E-06	NA	-	NA	-
Cyanide	6.9E-10	NA	-	NA	-
Iron	4.0E-06	NA	-	NA	-
Lead	1.7E-07	NA	NA	NA	NA
Magnesium	5.5E-08	NA	-	NA	-
Mercury	3.1E-10	3.0E-01	-	1.0E-09	-
Nickel	1.1E-07	NA	2.4E-04	NA	2.6E-11
Selenium	6.0E-10	NA	-	NA	-
Silver	1.7E-09	NA	-	NA	-
Zinc	1.8E-06	NA	-	NA	-
Total Risks				8E-06	3E-10

-	Not a carcinogen.
Ca	Predicted average concentration in air.
ELCR	Excess lifetime cancer risk (Ca x Unit Risk).
HQ	Hazard quotient (Ca/RfC); the hazard index is the sum of the HQs.
NA	Not available.
PAHs	Polycyclic aromatic hydrocarbons.
PCBs	Polychlorinated biphenyls.
RfC	Reference concentration.
Semi-VOCs	Semivolatile organic compounds.
ug/m3	Micrograms per cubic meter.
Unit Risk	Risk associated with breathing one ug/m3, 24-hours/day for 70 years.
VOCs	Volatile organic compounds.

CER 007708

GERAGHTY & MILLER, INC.

Table 10. Inhalation Risks and Calculations for Constituents of Concern, Nearest Residential Community, Southern Section of Dead Creek Sector B and Site M, Saugat-Cahokia, Illinois.

Constituent	Ca (ug/m3)	RfC (ug/m3)	Unit Risk (ug/m3)	HQ	ELCR
<u>VOCs</u>					
Acetone	4.9E-06	NA	-	NA	-
2-Butanone	8.6E-07	3.0E+02	-	2.9E-09	-
Carbon disulfide	2.5E-07	1.0E+01	-	2.5E-08	-
Chlorobenzene	8.7E-05	2.0E+01	-	4.4E-06	-
Ethylbenzene	3.0E-07	1.0E+03	-	3.0E-10	-
Tetrachloroethene	4.2E-08	NA	5.2E-07	NA	2.2E-14
Toluene	3.4E-07	2.0E+03	-	1.7E-10	-
Xylenes	2.1E-07	3.0E+02	-	7.0E-10	-
<u>Semi-VOCs</u>					
bis(2-Ethylhexyl)phthalate	1.2E-09	NA	NA	NA	NA
2-Chlorophenol	1.5E-10	NA	-	NA	-
1,2-Dichlorobenzene	1.1E-05	2.0E+02	-	5.5E-08	-
1,3-Dichlorobenzene	4.5E-06	NA	-	NA	-
1,4-Dichlorobenzene	2.7E-05	7.0E+02	NA	3.9E-08	NA
2,4-Dichlorophenol	3.5E-10	NA	-	NA	-
2,4-Dimethylphenol	2.0E-10	NA	-	NA	-
Isophorone	3.8E-10	NA	NA	NA	NA
4-Methylphenol	1.7E-10	NA	NA	NA	NA
PAHs (carcinogenic)	3.8E-08	NA	1.7E-03	NA	6.5E-11
PAHs (total)	8.1E-08	NA	-	NA	-
PCBs	1.1E-07	NA	NA	NA	NA
Pentachlorophenol	2.2E-09	NA	NA	NA	NA
1,2,4-Trichlorobenzene	1.1E-08	9.0E+00	-	1.2E-09	-
<u>Inorganics</u>					
Antimony	6.3E-08	NA	-	NA	-
Arsenic	1.3E-07	NA	4.3E-03	NA	5.6E-10
Barium	1.2E-05	5.0E+01	-	2.4E-07	-
Cadmium	2.7E-07	NA	1.8E-03	NA	4.9E-10
Calcium	2.7E-05	NA	-	NA	-
Chromium	1.7E-07	2.0E-03	1.2E-02	8.5E-05	2.0E-09
Cobalt	4.1E-08	NA	-	NA	-
Copper	3.4E-05	NA	-	NA	-
Cyanide	1.7E-09	NA	-	NA	-
Iron	1.0E-04	NA	-	NA	-
Lead	2.9E-06	NA	NA	NA	NA
Magnesium	5.6E-06	NA	-	NA	-
Mercury	3.9E-09	3.0E-01	-	1.3E-08	-

Footnotes appear on page 2.

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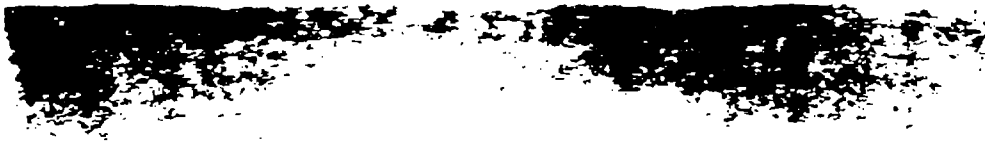
Table 10. Inhalation Risks and Calculations for Constituents of Concern, Nearest Residential Community, Southern Section of Dead Creek Sector B and Site M, Saugat-Cahokia, Illinois.

Constituent	Ca (ug/m3)	R/C (ug/m3)	Unit Risk (ug/m3)	HQ	ELCR
<u>Inorganics (continued)</u>					
Nickel	3.2E-06	NA	2.4E-04	NA	7.7E-10
Selenium	9.7E-09	NA	-	NA	-
Silver	5.2E-08	NA	-	NA	-
Zinc	5.0E-05	NA	-	NA	-
Total Risks				9E-05	4E-09

-	Not a carcinogen.
Ca	Predicted average concentration in air.
ELCR	Excess lifetime cancer risk (Ca x Unit Risk).
HQ	Hazard quotient (Ca/R/C); the hazard index is the sum of the HQs.
NA	Not available.
PAHs	Polycyclic aromatic hydrocarbons.
PCBs	Polychlorinated biphenyls.
R/C	Reference concentration.
Semi-VOCs	Semivolatile organic compounds.
ug/m3	Micrograms per cubic meter.
Unit Risk	Risk associated with breathing one ug/m3, 24-hours/day for 70 years.
VOCs	Volatile organic compounds.

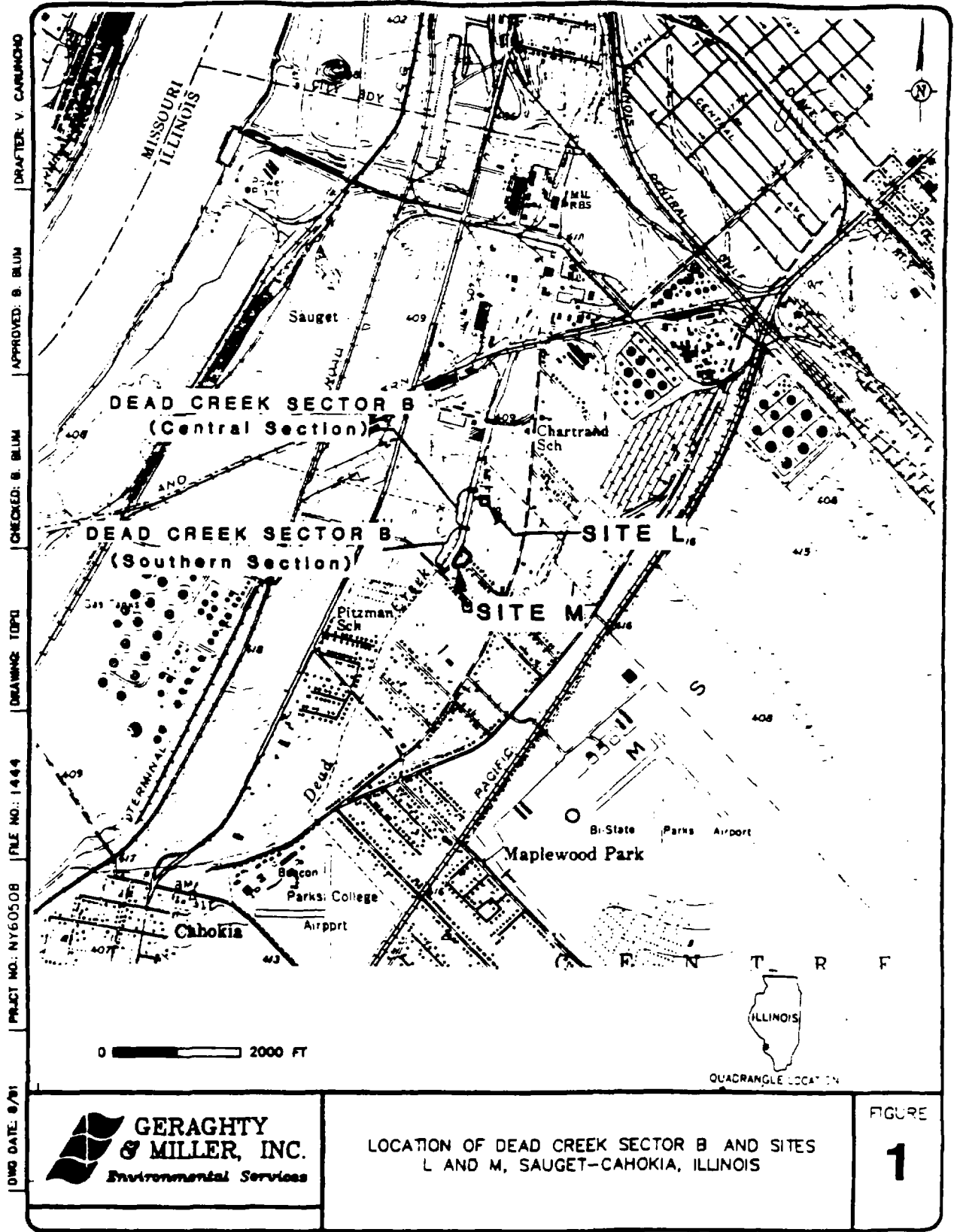
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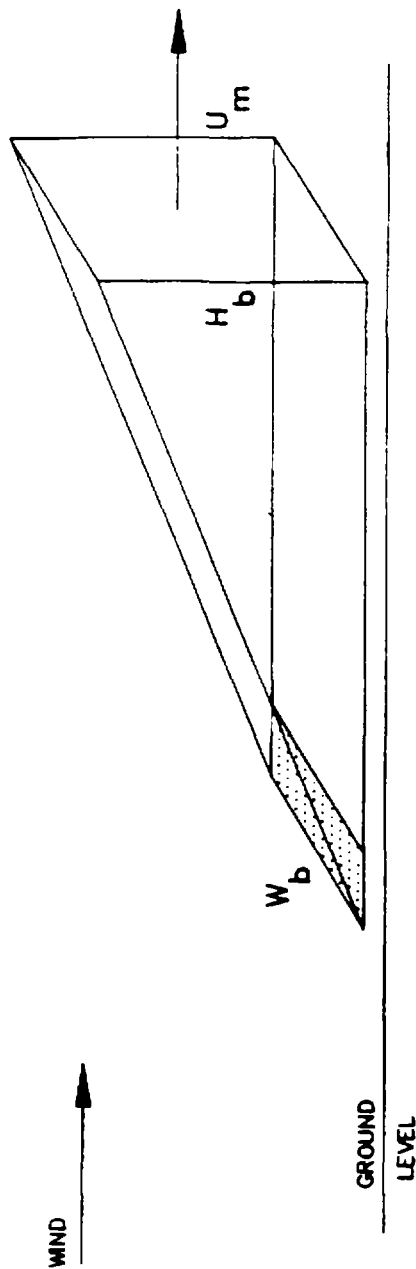


FIGURES

CER 007711



CER 007712



$$C_{voc} \text{ or } C_{part} = \frac{Q}{H_b \times W_b \times U_m}$$

Where

C_{voc} Ambient air concentration for volatile organic compounds.

C_{part} Ambient air concentration for particulates.

Q Modeled rate of VOC or PM10 emissions from soil (ug/sec).

H_b Downwind height of box is estimated to be 2 meters.

W_b Width of box, crosswind dimension of affected area, estimated to be 225 meters.

U_m Average wind speed through box (4.2 meters/sec).